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THE MOUNTAIN PINE BEETLE
and
THE BLACK HILLS BEETLE

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WHAT IS THE NAME OF THE INSECT WHICH KILLS MATURE LODGEPOLE PINE TREES THROUGHOUT THE WESTERN UNITED STATES?

Though there are several insects which attack and kill lodgepole pine, the most important, and the ones against which control measures are instituted, are the mountain pine beetle and the Black Hills beetle. Their scientific names are Dendroctonus monticolae Hopk. and Dendroctonus ponderosae Hopk. The word Dendroc-to-nus means "killer of trees", while mon-tic-o-lae and pon-der-o-sae are taken from the scientific names of white pine, "pinus monticola" and ponderosa pine, "Pinus ponderosa". The last word, "Hopk.", is an abbreviation of Hopkins, the man who first recorded and named these two insects.

WHY ARE SCIENTIFIC NAMES OF INSECTS NECESSARY?

As the common names of insects vary for different localities, it is necessary to have one recorded name that can be used in order to avoid confusion. As an example, the mountain pine beetle is often called white pine beetle, pine beetle, lodgepole beetle, pine engraver, etc., and as these names are also applied to other insects, considerable confusion is avoided by using the scientific name.

IN WHAT PART OF THE UNITED STATES ARE THESE INSECTS FOUND?

The mountain pine beetle is found throughout the States of Oregon, Washington, California, western Nevada, Idaho, western Montana, and northwestern Wyoming. The Black Hills beetle is found in southeastern Montana and western South Dakota, and through Wyoming, Colorado, Utah, New Mexico, and Arizona.

HOW DESTRUCTIVE ARE THESE INSECTS?

Within the forests of Idaho and Montana, epidemics of this insect during the past ten years have destroyed approximately 110,000,000 B.F. of white pine, and 5,000,000,000 B.F. of lodgepole pine. On one forest in Montana over 17,000,000 trees were killed during the 1933 season. The epidemic responsible for this destruction has also destroyed a large per cent of the mature lodgepole pine stands of Idaho and Montana. In these devastated lodgepole pine forests one may travel for miles through dead forests. Similar losses of equal severity have followed recent outbreaks of this insect within the lodgepole forests of the Pacific States.

The Black Hills beetle is equally as destructive as the mountain pine beetle, with a long record of destructive outbreaks. The first known

epidemic of this insect occurred in the Black Hills of South Dakota in 1895. In the few years following this outbreak, over two billion board feet of ponderosa pine were destroyed. During subsequent years epidemics have occurred from time to time throughout the entire range of this insect. A severe outbreak occurred on the Kaibab National Forest in 1917, and in the following eight years destroyed approximately 300,000,000 board feet of valuable timber.

DO THESE INSECTS ATTACK OTHER TREES BESIDES LODGEPOLE PINE?

The mountain pine beetle attacks white pine, lodgepole pine, sugar pine, ponderosa pine, whitebark pine, limber pine, and sometimes Engelmann spruce when it occurs in association with pine.

The Black Hills beetle attacks ponderosa pine, lodgepole pine, pinon pine, limber pine, Mexican white pine, bristle-cone pine, Engelmann spruce, and blue spruce. Of these many hosts, ponderosa pine is recorded as the preferred host.

OF WHAT IMPORTANCE IS THIS DESTRUCTION?

In addition to the monetary loss of the timber itself, there are such intangible items as the creation of dangerous fire conditions, loss of scenic values, watershed protection, game protection, etc.

When epidemics of these beetles occur in lodgepole pine forests, a large percentage of the stand may be destroyed. These standing dead trees fall down in the course of a few years, making an impenetrable tan gle of logs and tops. Under proper conditions a flash of lightning or a carelessly tossed match or a cigarette may set off the mass, resulting in a widespread conflagration almost impossible to control.

Old snags of insect-killed trees, often as many as 10 per acre, scattered throughout our mature forests stand for many years, and greatly increase the danger of fire control. Snag-felling is now required in many sales of National Forest timber, and many private operators have also adopted this regulation. The increased cost of control of fires which have spread from burning snags within fire lines would alone justify insect control even at a high cost.

The importance of adequate forest cover in National Parks, recreational areas, and game preserves can not be estimated in monetary values. Here the scenic and protective values far exceed that of the commercial timber.

Another less appreciated phase of the activity of these beetles is the part which they play in changing forest types. In both white pine and lodgepole pine forests these insects, through their destructiveness, so affect the proportion of species in these stands as to convert the resulting forests into one of an entirely different composition, usually of less commercial value.

WHAT ARE THESE TWO BEETLES LIKE?

Both the mountain pine beetle and the Black Hills beetle are rather stout, cylindrical beetles varying in length from .2 to .35 of an inch. When mature the color varies from dark brown to black, but by the time the first attack is completed they are usually all black. The immature stages in their development are egg, larva, and pupa. The larva when full grown is about the same size as the beetle, and is white and legless, with a small yellow head. The pupa, or the transition between the larva and new adult, is also white. As it develops the pupa gradually assumes the form, shape, and color of a new adult.

These two insects, as well as the gallery pattern of their work, resemble each other very closely, and can only be separated by a trained specialist. As the ranges of these two insects are distinct and do not overlap, the usual procedure is to use the locality where the insect occurs as a means of identification.

HOW DO THESE INSECTS DESTROY A HEALTHY TREE?

The female beetle bores through the bark and constructs a long, straight gallery directly beneath the bark, which slightly grooves the surface of the wood and extends up the tree, nearly always following the grain of the wood. At the base of these galleries, which always extend up the tree, there is a short crook, or bend, an inch or two in length. The perpendicular portion of the gallery, which varies in length from 9 to 36 inches, nearly always follows the grain of the wood.

During the construction of this gallery, eggs are deposited in small niches along the sides. These eggs hatch in a few days into small grubs, or larvae, which excavate short feeding tunnels at right angles to the egg gallery. The feeding tunnels vary in length from 1 to 3 inches, and are exposed on the inner surface of the bark. When fully grown the larva constructs a small pupal cell at the end of the larval mine, in which it transforms to a new adult. This transformation is what is called the pupal stage. The galleries constructed by this insect result in the girdling of the tree, which causes its death.

HOW MANY OF THESE ATTACKS ARE REQUIRED TO KILL A HEALTHY TREE?

The number of these beetles required to kill a healthy tree depends entirely upon the size and vitality of the tree attacked. Under normal conditions the number of attacks per square foot of bark surface varies from 5 to 11, with an average of 9 for the mountain pine beetle and about 6 for the Black Hills beetle.

HOW RAPIDLY DO THESE INSECTS INCREASE?

Though normally there is but one generation of the mountain pine beetle each year, during long seasons there is sometimes a partial second generation of the mountain pine beetle in white pine and ponderosa pine. By generation is meant one brood from egg to adult. The number of eggs laid by these beetles varies for the different species. The mountain pine beetle will average some 80 eggs per gallery, while the Black Hills is

recorded as averaging 15% or more in ponderosa pine. And as the mountain pine beetle constructs two egg galleries, the number of eggs laid by each species is practically the same. As there are an equal number of males and females, this would give an increase of 1 to 40 for the mountain pine beetle and 1 to 75 for the Black Hills beetle. Though this is the maximum potential increase each year, it is indeed fortunate that it does not occur. Such an increase would mean that for each tree attacked this year by the mountain pine beetle there would be 40 attacked next year, 1,600 the second year, and so on until all our pine would be destroyed in a very few years. There is a very high mortality of the developing brood as a result of parasitic and predacious insects, adverse weather condtions and woodpeckers, so that only about 8% of the maximum brood ever reach maturity and emerge. In addition to this mortality, there is what has been called a flight mortality caused by birds and mammals which feed on the beetles as they migrate from one tree to another. So it is very seldom that we ever have an increase in an infestation amounting to more than 250 or 300 percent, or 2 or 3 trees attacked this year for each one attacked last year.

DO WE ALWAYS HAVE INFESTATIONS OF THESE BEETLES?

As these two species of bark beetles are indigenous to this country, they are always present within our forests. Under normal conditions they occur in what has been called a normal or endemic infestation. Such conditions exist when all of the different elements of nature are so balanced one against another that one insect can not maintain supremacy over its enemies for any great length of time. This condition is called a biological balance, and applies to all animal life. From time to time these normal infestations increase into destructive epidemics. Such abnormal conditions are the result of the failure of certain factors which have previously contributed toward holding the injurious insect in check. It is often difficult to isolate the exact cause of such outbreaks, as there are a number of such environmental factors. Some of the most important may be listed, as precipitation, temperature, predacious and parasitic insects, and abnormal quantities of attractive host material, such as blow-downs, slashings, etc. Therefore, the above question can be answered by saying that though we always have what is called a normal loss of timber resulting from attachs of these two destructive beetles we do not always have epidemics.

HOW LONG DO EPIDEMICS LAST?

The answer to this question is indefinite. Insect epidemics last as long as there is a supply of host material remaining, or until nature restores a proper balance of the different factors involved. Some outbreaks are relatively short-lived, while others last for many years.

CAN EPIDEMICS OF THESE INSECTS BE PREVENTED?

Though perhaps epidemics of the mountain pine beetle and the Black Hills beetle can never be eliminated, their occurrence can be minimized. As the practice of forestry becomes more intensive, and our knowledge of the factors which have a bearing upon epidemic conditions increases, our forests can be kept in a more thrifty growing condition more resistant to

insect attack. The prompt harvesting of mature timber will also contribute to the lessening of timber losses as a result of insect attack.

WHAT CAN BE DONE TO PREVENT THESE SERIOUS LOSSES OF TIMBER?

The loss of commercial timber resulting from the attacks of the mountain pine beetle and Black Hills beetle can be reduced to a minimum through the prompt institution of artificial control. Areas of valuable timber must be kept under constant observation, and at the first sign of an increase in the infestation artificial control should be instituted.

CAN TREES BE SAVED AFTER THEY HAVE BEEN ATTACKED BY THESE BEETLES?

When a tree has been successfully attacked, it can not be saved, though its foliage may remain green for some months. The insects have become firmly established beneath the bark, and their removal is impossible.

IF TREES CAN NOT BE SAVED AFTER ATTACK, OF WHAT BENEFIT IS CONTROL?

Artificial control measures are directed toward the destruction of the insect broods beneath the bark of trees which are already killed, to prevent their emergence and attack of other trees.

HOW CAN ARTIFICIAL CONTROL BE ACCOMPLISHED?

There are a number of direct methods of artificial control, all of which successfully destroy the insect broods beneath the bark. Though infested lodgepole pine can be felled, decked, and burned, the most efficient method is to burn them standing. This is accomplished by spraying an inflammable oil upon the trunk of the tree, which is then burned. When trees can not be burned to the height of the infestation, it is necessary to fell them for further treatment. Lodgepole pine are often infested up to a 6-8 inch top diameter, so when trees are not burned to this height, they are felled for subsequent treatment. Infested white pine or ponderosa pine trees are felled, the infested portion of the bole cut into logs, which are decked and burned. If the insect broods are in a larval stage, the peeling of the bark from the infested logs will destroy the insects.

IS THERE NOT CONSIDERABLE DANGER IN THE USE OF FIRE?

Care must be exercised at all times in the use of fire in our forests. It is often necessary to close control operations or change to a peeling method of control. Log decks must be properly trenched before burning, and tended until safe. During bad fire weather, decks can be burned at night with a fair degree of safety.

DOES NOT THE USE OF FIRE DESTROY BENEFICIAL INSECTS AS WELL AS THE DESTRUCTIVE PEST?

It is obvious that this is an objection to our present methods of control. To overcome this objection and to preserve these beneficial insects so as to aid nature in restoring a properly balanced condition within the forest, white pine trees showing a certain percentage of parasitism are now left untreated in all control projects directed against the mountain pine beetle in that tree species. Such trees are left untreated on

the basis that the beneficial insects that are preserved will aid in reducing the epidemic to a normal status. As yet we are unable to institute this practice in the control of these insects in lodgepole pine, though it is hoped that future studies will permit the administration of such operations in a manner which will preserve the beneficial insects.

WHAT IS THE MOST IMPORTANT TASK OF A CONTROL OPERATION?

Spotting, or the location of infested trees, is the first and most important step in all bark-beetle control projects. Its importance is twofold, as it demands the location of all infested trees within an area, as well as the proper selection of them for treatment after they have been located. Of the two the latter is perhaps the more complicated. The location of infested or insect-attacked trees is but a mechanical operation, which, if one is alert, can be made 100 percent effective. The problem of determining whether a tree showing the external signs of bark-beetle attack should be marked for treatment presents more serious difficulties. Briefly, it is the duty of the spotters to locate as efficiently and economically as possible all infested trees which require treatment. The importance of this task will be appreciated when it is understood that infested trees missed by spotters become a potential source of reinfestation, which often defeats the purpose of the operation.

HOW DO YOU RECOGNIZE TREES THAT HAVE BEEN ATTACKED BY THE MOUNTAIN PINE BEETLE AND BLACK HILLS BEETLE?

Insect-attacked trees can be recognized by the small pitch exudations (pitch tubes) which form at the mouth of entrance holes, or from boring dust around the base of trees or in bark crevices. When the attack is extremely heavy, the pitch tubes are small or absent entirely, so their presence can not be depended upon as an infallible guide to infested trees. This condition can be explained by the fact that the flow of pitch through so many entrance holes is not sufficient to form tubes. On the contrary, with light attacks the flow of pitch through the few holes is so strong that attacking beetles are often washed from their galleries. Large pitch tubes are usually, though not always, an indication of pitched-out attack. Fresh woodpecker work is a true indication that there were and possibly are insects beneath the bark. However, it does not prove that the insect is the mountain pine beetle or Black Hills beetle.

In marking trees for treatment one will often be called upon to distinguish the work of these two beetles from that of other species of bark beetles, particularly those of the genus Ips.--the pine engraver beetle. In making such decisions the safest rule to follow is to familiarize oneself with the characteristic gallery pattern of these two species. A point to be remembered is that the egg gallery, or main channel, of all Dendroctonus beetles is always packed solid with sawdust, except for an inch or two at the upper end, while with Ips species the forked galleries are kept free from sawdust.

There is no infallible rule which can be given for the proper marking of infested trees from external evidence. Such evidence will lead one to trees that have been attacked, but more thorough examinations are necessary to determine if they should be marked for treatment. It will be

necessary to examine every infested tree be removing a piece of the bark. If the tree was killed by the mountain pine beetle or Black Hills beetle and there are sufficient of these insects beneath the bark, then it should be marked for treatment, provided it is not a parasite tree which must be left untreated. Beetle broods may be found as larvae, pupae, or new adults. Parent adults will be found in the top of the egg gallery. Do not mark trees for treatment on the strength of these old black parent adults alone, as they carry very little, if any, potential danger to green trees adjacent. New adult beetles vary in color, appearing first as pure white to brown and then to dark black prior to emergence.

HOW CAN ALL OF THE INFESTED TREES WITHIN A FORESTED AREA BE LOCATED?

In order to locate all infested trees within an area, it must be systematically covered by a spotting crew.

WHAT ARE THE DUTIES OF A SPOTTING CREW?

The duties of a spotting crew vary with the character of the operation. If the trees are first located by a spotting crew, and subsequently treated by a treating crew, the spotters in addition to locating and marking the infested trees for treatment must construct a map showing the location of the marked trees. However, in treating lodgepole pine, the usual practice is for the spotting crew to treat the infested trees as they are located, which eliminates the necessity for a map.

HOW ARE SPOTTING CREWS ORGANIZED, AND WHAT EQUIPMENT IS REQUIRED WHEN MAPS ARE CONSTRUCTED?

The usual organization for this work is a six-man spotting crew consisting of one chief spotter, one compassman, and four spotters. Each spotter, including the chief spotter, is equipped with a hand ax and sheath, marking crayon, and sufficient tags and tacks for one day's work. Tags should be at least 3" x 4" in size, and of a bright color (yellow or white), so that they can be seen easily by the treaters.

The compassman is equipped with a standard staff compass, staff, 2 tally registers, one 5" x 8" tatum holder, map sheet, protractor, and pencil.

HOW DO SPOTTING CREWS OPERATE WHEN A MAP IS TO BE CONSTRUCTED?

Spotting crews gridiron a section or block of timber by traveling back and forth on a definite compass line. Trails, roads, streams, ridges, etc., can be used for base lines when spotting is being conducted in unsurveyed country or where the timber type is more or less broken into small blocks. As the direction of a strip is reversed, the spotter who was on the outside should return on the inside of the new strip so that he will be covering familiar ground, and will not permit areas to be missed between the two strips. As strips cross main trails or roads, it is a good plan to fasten to a tree or stump a tag showing the number of the strip. The strip can be identified from spotters' maps, and such information often proves to be of assistance to treating-crew foremen in re-locating marked trees.

It is difficult, in fact impossible, to visualize all types of conditions in order to offer tentative solutions. It will often be necessary for chief spotters to make immediate decisions upon the ground. If one bears in mind that the task of spotting is the location of infested trees for the treating crews, there will be no question but that such decisions will be correctly made. A method of spotting which does not locate such trees so they can be re-located with the least possible effort is in most cases an improper one to use. Good judgment must of course be considered in making all decisions in order that spotting will not be carried to an unwarranted extreme.

The chief spotter is charged with the proper conduct of his crew. He must exercise constant supervision over the compassmen and spotters in order that their work be properly performed. In addition to the supervision of his crew the chief spotter will be charged with the submission of required reports, maps, etc.

The compassman will be responsible for the compass work, pacing of distance traveled, and the construction of a map showing the number and location of all trees marked for treatment.

Each spotter is responsible for the examination of all trees on a strip one chain wide on one side of and parallel to the course of the compassman. The two inside spotters guide on the compassman, and the two outside spotters guide on the inside spotters, so that they can maintain a proper alignment or formation. The best results are secured when the crew maintains a slightly V-shaped formation. In this manner the strips are held to a width of one chain, which in dense timber stands has been found to be the maximum width that can be covered if every tree is examined properly. The need for examining every tree has been explained under the heading "How do you recognize trees that have been attacked by the mountain pine beetle and Black Hills beetle?" When an infested tree is selected for treatment, the spotter fastens a tag, on which is written the tree number given him by the compassman and his own initials, to the tree by tacking the two upper corners. In addition to the tag a blaze is placed on the opposite side of the tree, on which is also written the tree number and the spotter's initials.

The chief spotter works over the entire 4-chain strip behind his crew, and is responsible for the alignment of his organization, the correct marking of all trees for treatment, and in fact the entire activity of the crew. In this way he is able to supervise the men properly, and it is only through efficient and adequate supervision that effective spotting can be secured.

The usual method of operation employed is for the compassman to proceed slowly until one of the spotters shouts "Bugs", which indicates that he has located an infested tree. The compassman then stops, and if the tree is selected for treatment, calls a number to the spotter, and maps the location. The tree numbers should be consecutive so as to facilitate their location by the treating crews. When a group of trees is located, a circle showing the location of the group and the included numbers, such as 17-24, will be used to show their location. The compassman should progress as slowly as necessary

to permit the spotters to examine all trees thoroughly on their strips. When the end of the strip is reached, the compassman offsets 4 chains, and returns on a parallel strip in the same manner. The inside spotter should always be the man who on the previous strip was on the outside, as he will be familiar with the territory being covered. At the end of the day's work the map constructed should be transferred to what will be the completed map. The number of copies of this map which will be required will vary, though usually there will be one copy for the camp manager, one for each of the treating crews working in the area covered by the map, and one for the office files.

It is often erroneously assumed that the presence of red-tops can be used as a guide to locate new attacks, and that it is not necessary to cover the entire area. This is an improper belief, as such a procedure will not locate new spots of infestation where there is no discolored foliage.

HOW DO SPOTTING CREWS OPERATE WHEN NO MAPS ARE CONSTRUCTED?

When the spotting crew does not make a map, it is necessary for the spotting and treating to be performed in one operation. The crew works in much the same manner as a regular spotting crew, though no compass lines are run or distances paced. The method used to insure the coverage of the entire area is for the outside man on the strip to make a paper trail by sticking a half page of an old magazine to a twig every fifty feet or so. This trail can be easily followed on the return strip. The man following the paper trail acts as the guide for the remainder of the crew, and each spotter guides upon the man nearest to the one acting as guide. The best formation is for each spotter to keep a little behind the man he is guiding upon. This assures a proper alignment and a thorough coverage of the entire area. The chief spotter follows behind the crew, and is responsible for the character of their work. When infested trees are located, the same procedure is followed as outlined for the other method of spotting, except of course that the trees are treated instead of being marked. With this method of spotting the only equipment that the spotters carry is a hand ax, which is used in the examination of trees. Necessary treating equipment is carried by pack horses.

HOW DO TREATING CREWS OPERATE, AND WHAT EQUIPMENT IS REQUIRED?

As the organization of treating crews varies with the different methods of treatment, this question can only be answered by discussing each one separately:

Felling and Burning Infested Trees

Treating crews engaged in the felling and burning of infested trees usually consist of six men, which include a crew leader, two sawyers, and three swampers. Each treating crew foreman will have charge of two such crews, and will be responsible to the camp superintendent for their work. Sawyers are equipped with a 5- or 5-1/2- foot crosscut saw, two small felling wedges, and a double-bitted ax, while each swamper carries an ax and a canthook.

Treating crews under each foreman must not work so close together that they interfere with each other, nor so far apart that adequate supervision on the part of the foreman is difficult. The crew foreman uses the spotter's map to re-locate the trees marked for treatment, and directs his crew leaders to them. He must plan the day's work so that there will be the least possible time lost in traveling from one infested group of trees to another. The foreman is responsible for treating all trees marked for treatment, as well as the proper burning of the log decks. When trees are located that have been missed by the spotters--that is, infested trees that have not been marked for treatment or marked to be left as parasite trees--they will be treated and listed as extra trees.

The sawyers are charged with the removal of spotters' tags from trees treated, and with marking the tree number upon the stump, which provides a means of checking if necessary. The tags are turned over to the treating-crew foreman, who in turn passes them on with his "Crew Foreman's Daily Report" to the camp superintendent.

While the first tree is being felled, the swampers prepare a place for the log deck, which must be of sufficient distance from green trees to prevent scorching. When the deck location is selected, dry poles or limbs should be placed flatly upon the ground. When the trees are felled and cut into convenient, uniform lengths, the swampers roll them onto the dry material, packing them as closely as possible, so that no large holes or spaces occur either on the deckor under it. Decks must not be piled crosswise on skids. This leaves a space between the deck and ground, and as soon as the dry material burns up, the fire will almost invariably go out.

After the sawyers have finished a group of infested trees, they go to the next as directed by the foreman. The swampers will remain and complete the decking and preparations for burning by piling dry limbs and slash around small decks to assure a good burn. Fire should be started at the lower end of all decks. Stumps must be peeled. If any fire hazard exists, all decks must be trenched, and no fires started until late in the afternoon or at some time when conditions are more favorable. When decks are not burned as constructed, they must be tagged in the same manner as an infested tree. The crew foreman must also construct a map showing the location and the number of each unburned deck. The tag is placed on a nearby tree, and is collected by the work supervisor when his inspection shows that a complete burn of all infested material has been accomplished.

After a deck of infested logs has been fired, it must be tended regularly until all infested bark surface has been burned. One man is usually detailed to watch several decks, and he rolls unburned portions of logs together before the fire burns out. It is best to fire large decks late in the afternoon, as they will burn all night and there will still be enough fire left the following morning with which to burn the unscorched portions of the logs. As smaller decks burn much faster and need more attention, it is best to fire them in the morning in order that they can be tended during the afternoon.

During seasons of relatively high fire hazard, night burning must be resorted to. Decks are built and trenched by treating crew during the day, but are burned during the night by two or three men. Fires are

started about 7 o'clock in the evening, and are watched all night. By rolling the burning logs together, the fire is fairly safe by morning, and with care there will be no danger of the fire spreading. However, such decks must be watched during the following day or until the fire is out.

Whenever possible horses should be used to skid the infested logs into decks for burning. In steep, rough country it is usually necessary to hand log.

Felling and Peeling Infested Trees

This method is not recommended except where conditions do not permit the use of fire. The most efficient organization depends upon the character of the infestation being treated. In heavy infestations larger crews can be used than when scattered trees are being treated. The equipment consists of felling tools, axes, peeling spuds, and canthooks. This method of treatment is effective against the immature stages of bark-beetle broods. Care must be exercised in the removal of the bark so that it is cleanly separated from the wood. To peel the under side of the bole, a few cuts are often necessary to permit rolling.

Burning Infested Trees Standing

This method is usually employed where spotting and treating are performed in one operation; however, at times crews may operate as actual treating crews in burning large groups of infested trees, or under other circumstances. But regardless of where the treating is done, the equipment and technique of operation are the same. Though this method may appear simple in its operation, a lot of skill is required in order to secure efficient and economical treatment.

The object to be obtained in this method is to generate sufficient heat on the bark of the tree to kill the developing broods of young beetles which are working between the bark and the wood. The effectiveness is very largely dependent on the care exercised and skill developed in the application of the oil to the trunk and the handling of the fire. Tops, bases or other sections of the trunks containing broods which are insufficiently treated defeat the purpose of a lot of other very effective work. The insects occur principally in the main bole of the tree and seldom in any tree or section under six inches in diameter. Sometimes they may be on only one side of a tree.

The equipment used consists of compressed air sprayers of four gallons capacity equipped with carrying strap, oil-resistant hose connection to an automatic shut-off and a long nozzle having an aperture the size of a No. 55 drill. Careful experiments have demonstrated that this size and form of nozzle gives best results with the oil. The light fuel or gas oil used has somewhat the burning qualities of kerosene, but costs considerably less. In timber where the infested portion of a tree extends to a height of 20 feet or more, particularly where the boles are clean and free from limbs, it is necessary to use steel extensions which are made in sections three feet long. By coupling three of these together the oil may

be thrown somewhat in excess of 30 feet high. Cases are provided so that several sections of the extensions may be carried with the pack outfit supplying the burners with oil.

Though the crews for this work will vary in size depending upon the character of the infestation being treated, the most efficient organization consists of one foreman, three to four burners, and a packer with the necessary pack horses. The packer keeps a supply of oil at hand for the burners by packing from a supply which is either hauled out in the drums or packed to some point in the general vicinity of the work. The foreman besides supervising the work of the burners checks up the location of scattered trees, locates groups of trees ahead of the burner, checks the distribution of the oil supply for future work, and keeps watch for infested trees missed by either spotters or burners. The foreman will have plenty to do in keeping the work so lined up that the burners can walk directly from one group to another without waste of time or effort, and in getting the work done right. One hundred percent perfect treatment is the objective. He is directly responsible for all tagged trees on an area being properly treated. If marked for treatment, the burners gather the tags from trees as treated, apply the oil and carry out the burning under the direction of the crew foreman.

The tanks are filled about three-fourths full of the oil, and pumped up to a moderate pressure. Too high pressures cause breaking up of the oil stream. A few tests will give the burner an idea of the feeling of the pump when the most effective pressure is obtained, which is about 20 pounds, and as far as possible this pressure should be maintained at this point. For most men the tank is carried more effectively on the left shoulder at an angle of about 35° with the body. The automatic shut-off is operated by the right hand. The oil is rather caustic, and will blister the skin if it comes in contact with it to any considerable extent. For this reason the clothing should be such as will give good protection, and spilling of the oil on the clothes or hands should be avoided as far as possible. Burners are required to carry a large rag to wipe the oil off the outside of the tank after filling. The rag can be carried between the lower end of the strap and the tank, where it will dry out sufficiently for long use. Extra clothing should be available to allow changing, since more or less spattering with oil is unavoidable. Unguentine should be used freely where burning has occurred. Precautions should be taken to see that oil-soaked clothing does not become ignited.

The height to which trees should be treated is a difficult question to answer. With small trees one can be reasonably sure as to the height of required treatment. However, with large trees it is not so easy, as it is impossible to tell how high the infestation extends. However, there are a number of factors which can be used in answering this question:

1. There is a distinct relationship between the average height of brood and the diameter of the bole at that point.

2. Infested trees occurring in groups are often infested to a greater height than single trees.

3. The larger and taller trees are often infested to a greater height than those with smaller diameters.

4. When trees are treated up to a 7" top diameter, 99.7% of the infestation will be destroyed.

5. Trees with heavy basal attacks show a greater height of infestation.

6. Trees attacked on one side seldom show a very high infestation.

Before starting to throw the oil on a tree, the tank should be examined to see that there is sufficient oil and air pressure to complete the application. A stream of oil is directed against all parts of the trunk up to the desired height, care being taken to distribute it evenly and avoid spattering. The base of the tree often has thicker bark, and particular care must be taken to soak this section thoroughly. Since it is desired to create intense heat and burn out the entire top if possible, advantage should be taken of any heavy or dry limbs close to the trunk and oil sprayed on them. When there is considerable wind it is necessary to thoroughly soak the side of the trunk towards the wind, and oftentimes it is better to use little or no oil on the side away from the wind except at the base of the tree or until after the fire is started. If there are two or more infested trees standing close together, they should be sprayed and burned at one time, as the added heat results in a better burn.

The best results are secured when the burners work in pairs, especially for the treatment of large trees. One tank is equipped with extensions, and is used to apply the oil to the bole of the tree above the point which can be reached by the other burner. With the aid of the extensions (with tall trees three of these are used), an additional sprayed height varying from 7 to 9 feet is secured. After the tree has been properly sprayed on all sides, both burners see that there is oil within their tanks and that sufficient pressure is available before the fire is started. A lighted match is then applied to the base of the tree, and the flames carried upward with the aid of additional oil. Just as the flames reach the top of the sprayed portion of the bole, the tank with the extensions is used to apply some additional oil at this point, which in many instances will force the flames several feet higher and often develops sufficient heat to force the flames through the crown. When a good flame is developed quickly, a better burn follows than when it becomes necessary to attempt to build up the flame after the bark has been partially burned. In order to destroy the insects beneath the bark, it is necessary to burn it so severely that the edges of the bark flakes appear white. Trees with heavy bark need more severe treatment. A few dry limbs or brush thrown around the base of large trees insure a thorough treatment at the base, and assist in forcing the flames up the bole. Large limbs or logs should not be placed around the base of the trees, as they burn too long and often result in hold-over fires.

When the bark is cold or immediately following storms a greater amount of oil is necessary than when the trees are warm and dry. Green

trees also require more heat than those that are dried out. Where any doubt exists as to the use of extensions, they should always be used. It is much more effective to use them and burn out the tree at one burning than to have to go back and attempt to burn out the top after the lower part is burned. Sometimes poles or brush placed against the base of the tree helps to carry the fire up. Do not hesitate to ask the crew foreman whenever there is any question regarding whether or not the burning is being properly done. When trees have not been treated to a sufficient height, they must be felled for further treatment if all of the insects are to be destroyed. Cold winds greatly reduce the effectiveness of burning, and at times it may be necessary to burn in the evening or at night. The same action may be necessary during dry periods when the use of fire becomes dangerous. Early morning or evening hours can often be safely utilized for the treatment of trees in areas where bad fire conditions exist. Such areas can also be rather safely treated following rains or showers.

Avoid: Wasting oil.
Useless treatment.
Skipping infested sections.
Insufficient heat at base.
Missing any bug-infested tree.
Lighting before you are ready.

Do: Reach all infested sections of the tree.
Distribute the oil evenly and thoroughly.
Make sure you have oil and air pressure to build up heat after lighting.
Build up a quick heat.
Make sure the heavy bark at the base of the tree is well treated.

HOW ARE TREES SPOTTED AND TREATED DURING THE SAME OPERATION?

This method is usually employed in the treatment of infested lodgepole pine when the trees are burned standing. A regular spotting crew is used to cover the area as outlined under "How do spotting crews operate when no maps are made?" The spray tanks, a supply of oil, and the necessary felling tools for large trees follow the spotting crews on pack horses. The spray tanks are carried in specially constructed pack boxes so that they can be easily removed. When infested trees are treated, the equipment is brought up and the spotters become burners until the trees are treated. The packer packs up his equipment, and the strip is continued. When this method of treatment is used, the men must be trained as both spotters and burners.

IS TREATING AN IMPORTANT OR DIFFICULT TASK?

Treating is an important phase of control, and its efficiency will have a direct bearing upon the success of the project. Obviously there would be no need to mark an infested tree for treatment if it is not to be properly treated. Poor deck construction is one of the most common causes of improper and expensive treating, and results in subsequent reinfestation. Care must be exercised in the location of log decks

so that green trees will not be scortched. Fire-injured trees are highly susceptible to future beetle attack. Stumps must always be peeled. When trees are burned standing, they must be burned to the height of infestation or felled for subsequent treatment. Thorough treatment of marked trees is essential.

WHEN DO THESE BEETLES ATTACK?

In white pine there are three general attack periods of the mountain pine beetle: the first in June; the second and main attack from the middle of July to the middle of August; and the last from late August to the end of the season. Approximately one year is required for each of these broods to develop; consequently the new adults from these attack periods emerge about a year later during the same period. The June brood pass the winter as new adults; the midseason and most numerous brood overwinter principally as large larvae and eggs. In addition to their original attacks, the parent adults re-emerge and made a second attack, nearly always on new trees. The second attack occurs approximately 20 days after the first, so with each attack period there are both new and parent adults from the previous period working together.

Practically the same conditions exist in lodgepole pine, though there are not very many overwintering new adults, which limits the number of June attacks; in fact, these are rather uncommon.

There is but one generation of the Black Hills beetle each year. During late July and August the adult beetles emerge from the trees which they attacked and killed the previous year. New attacks occur soon after emergence. Eggs are laid and the larvae are nearly full grown by the end of the summer. Pupae begin to appear by the middle of the following May, and new adults are present by June. Most of the overwintering brood of larvae have reached a new adult stage by the last of June, though there is little or no emergence until the latter part of July.

WHY CAN WE NOT SECURE ANOTHER INSECT WHICH WOULD DESTROY THE MOUNTAIN PINE BEETLE?

The above question, which is a perfectly logical and popular one, is always asked by those who are not familiar with insect life. This question is prompted by the knowledge that all insects, both injurious and beneficial species alike, have their own parasitic and predacious insect enemies. For example, the parasitic enemies of the mountain pine beetle are also preyed upon by other insects. Such an arrangement is necessary in order to prevent the parasites from eliminating the mountain pine beetle, which would be followed by the complete destruction of the parasites, as there would be no mountain pine beetles for them to feed upon. Likewise, if there were no parasites of the mountain pine beetle, this injurious pest would soon increase to such numbers as to destroy all of our pine. This arrangement of beneficial and injurious insects is nature's method of maintaining all of the different factors of a forested area in a properly balanced condition.

The use of parasitic or predacious insects in the control of an injurious pest is termed biological control. In the practice of biological control the entomologist has two possibilities, which are the utilization of local beneficial insects or the importation of such beneficial species from foreign territories. With the first possibility we attempt to administer our contol methods in such a manner as to preserve as many beneficial insects as possible. In white pine control work we do not treat those infested trees which show a certain percentage of the brood to be parasitized. We believe that by leaving these parasites they will increase to such numbers as to gain the upper hand of the injurious insect and restore conditions to a proper balance. To go further than this and to develop one of the native parasites to such an extent that they will completely control an outbreak of the mountain pine beetle seems to be impossible, as it would be necessary to eliminate all of the enemies of such a parasite to permit it to develop unhampered.

In considering the second possibility, or the introduction of parasites from a foreign territory, it is of course necessary to have some place to go to secure your parasites. The mountain pine beetle and the Black Hills beetle are natives of the western United States and Canada. They are found in no other place in the world. Therefore, we have no place to go to secure parasites which are not already in this region. The introduction of parasites for the control of insects which are indigenous, or native, to a territory, though perhaps not impossible, offers many difficulties. The only successful cases of control by parasites has been against injurious pests introduced into territories foreign to their native home. With such introduced species it is possible to go to the original home of the injurious pest and collect some of its most important parasites. These can be carefully collected so that their enemies are left behind. In this way some very successful examples of control by parasites have been effected. However, in all instances they were against introduced insects. Therefore, it would seem that all we can do in attacking epidemics of the mountain pine beetle is to so direct our control measures as to preserve as many parasites and predacious insects as possible as a means of helping them restore conditions to a proper balance.